

1981

Some Microeconomic Evidence On Money Neutrality

Walter Enders

Iowa State University

Barry Falk

Iowa State University

Follow this and additional works at: http://lib.dr.iastate.edu/econ_las_staffpapers



Part of the [Agribusiness Commons](#), [Economic Theory Commons](#), [Macroeconomics Commons](#), and the [Strategic Management Policy Commons](#)

Recommended Citation

Enders, Walter and Falk, Barry, "Some Microeconomic Evidence On Money Neutrality" (1981). *Economic Staff Paper Series*. 56.
http://lib.dr.iastate.edu/econ_las_staffpapers/56

This Report is brought to you for free and open access by the Economics at Iowa State University Digital Repository. It has been accepted for inclusion in Economic Staff Paper Series by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.

Some Microeconomic Evidence On Money Neutrality

Abstract

In this paper we provide some empirical support for the money neutrality implications of the Natural Rate Hypothesis (NRH). Traditionally, tests of the neutrality implications of the NRH have been concerned with measuring the effects (if any) of money supply changes on the economy-wide level of unemployment or real output. Directly related examples of work in this area include Barro (1977, 1978, 1981), Barro and Rush (1980), Gordon (1979), Hoffman and Schlagenhauf (1982), Leiderman (1980), Mishkin (1982), and Small (1979). Our point of departure from such tests is that we measure the effects of money supply changes on a particular industry.

Disciplines

Agribusiness | Economic Theory | Macroeconomics | Strategic Management Policy

SOME MICROECONOMIC EVIDENCE
ON MONEY NEUTRALITY

Walter Enders
and
Barry Falk

No. 128

Some Microeconomic Evidence on Money Neutrality

Walter Enders and Barry Falk*

I. Introduction

In this paper we provide some empirical support for the money neutrality implications of the Natural Rate Hypothesis (NRH). Traditionally, tests of the neutrality implications of the NRH have been concerned with measuring the effects (if any) of money supply changes on the economy-wide level of unemployment or real output. Directly related examples of work in this area include Barro (1977, 1978, 1981), Barro and Rush (1980), Gordon (1979), Hoffman and Schlagenhauf (1982), Leiderman (1980), Mishkin (1982), and Small (1979). Our point of departure from such tests is that we measure the effects of money supply changes on a particular industry.

Taking a microeconomic perspective enables us to consider the manner in which monetary shocks are vertically transmitted from the retail level, to the wholesale level and, ultimately, to the production level. Focusing our analysis on a particular industry does more than simply yield some insights into the transmission mechanism. The approach also avoids some aggregation and measurement problems which can make the empirical analysis more difficult. For example, monetary shocks might systematically alter relative prices, causing the composition of output to change but leaving total output unchanged. In this case it would appear, on the basis of aggregate data, that monetary shocks do not systematically affect real output. This

conclusion could be drawn, though in the case we just outlined, money would not be neutral in the usual sense.

In the next section of the paper some of the tests of the money neutrality implications of the NRH are reviewed. We then build the case for testing at the microeconomic level. The structure of the U.S. pork industry is discussed and we explain why it is a particularly appealing candidate for an industry test of money neutrality. In Section Three, we present our empirical results and interpret them. It is shown that anticipated monetary shocks do not have systematic effects on any stages of the industry's activities: pork production, pork inventories, and (implicitly) pork sales. On the other hand, unanticipated monetary disturbances seem to have systematic and economically plausible effects on all three stages. In particular, an unanticipated increase in the money supply leads to an increase in the number of pounds of hogs slaughtered. Concurrently, the number of pounds of pork bellies in storage decreases. Increased production and reduced inventories imply that retail sales increase.

A reasonable interpretation of the results is that positive unanticipated monetary shocks increase retail sales and reverberate quickly throughout the industry. The increased retail sales reduce the number of bellies in storage and increase the amount of meat from slaughtered hogs. Anticipated money supply movements, however, have no real effects. There are also some interesting results regarding the industry's adjustment in periods after the shock which, we believe, make our primary results more compelling. In the paper's final section, we summarize our results and discuss some directions for future research.

II. Testing Implications of the NRH

Many of the more commonly cited tests of the money neutrality implications of the NRH under rational expectations have, in one way or another, employed the Lucas (1973) supply mechanism in which economic agents do not simultaneously perceive all relevant prices within the economy.^{1/} Having limited price information, agents cannot clearly distinguish between absolute and relative price changes. Thus an increase in the general price level can be incorrectly interpreted as a relative price increase. By generating 'false' relative price signals, demand management policies can temporarily affect output. For example, a demand stimulus, such as a money supply increase, is likely to increase general prices. If, however, some individuals did not fully anticipate the money supply change and have not yet deduced it, they may attribute some portion of the general price level increase to an increase in an observed set of relative prices. If market supply is increasing in perceived relative prices, the money supply change will induce output increases. However, as the agent's information set expands and they learn about the general price level, output will return to its natural rate.

The hypothesis of rational expectations enters the model since agents are assumed to use optimal forecasting methods in their attempts to disentangle absolute from relative price movements. As such, the more variable the demand stimulus, the smaller the response of agents to an observed price change; as the variance of the demand stimulus increases, the portion of an observed price change which is attributed to a relative price change decreases. Lucas (1973) argued that the international evidence is consistent with this view of the NRH. His regression results indicate that

the more variable a nation's level of aggregate demand, the less favorable is that nation's trade-off between aggregate output and a demand shock.

Lucas' methods have been criticized on a number of well-known grounds which have raised doubts about the validity of his results. Most of these criticisms have focused on Lucas' assumption that his model of supply represented a stable (cross-country) structural model. Further, the casual insertion of lagged output into the supply model has drawn much fire. In addition, we will raise some questions regarding the appropriateness of using Lucas' model as a vehicle for testing implications of the NRH at an aggregate level.

Compelled by a desire to test the important monetary policy implications of the NRH, but frustrated by the difficulties involved in modelling the economy's structure in a way which is both theoretically attractive and econometrically tractable, macroeconomists have tried to design meaningful tests within the context of reduced-form models of output and/or unemployment. In a series of papers, Barro did groundbreaking work toward this end.^{2/} As Barro (1977, p. 101) states, "... the proposition that only the unanticipated part of money movements has real effects is clearly more general than the specific setting of these [Lucas (1972, 1973), Sargent and Wallace (1975) and Barro (1976)] models." Although the results obtained by this approach are not tied directly to Lucas' particular supply model, it seems unlikely that the neutrality implications of the NRH could be sustained in an economic environment which differed drastically in spirit from Lucas' setup.

Barro's test involved developing a forecasting model for the U.S. money supply. Anticipated money is defined as the forecasted value of the money supply while unanticipated money is the forecast error. Mathematically, if

the forecasting model is correctly specified, the anticipated component of the money supply in period $t+1$ will be the expected value of the money supply conditioned on information available at time t . Then, real GNP (and/or unemployment) is regressed on the generated, anticipated and unanticipated money supply variables (and, possibly, on other explanatory variables). Proceeding in this manner, Barro (1977, 1978, 1981) and Barro and Rush (1980) found apparent confirmation of the NRH implications regarding money neutrality. In particular, unanticipated money supply growth showed a strong, positive effect on real GNP and a negative effect on unemployment. But anticipated money supply increases showed no effect.

The importance of Barro's findings has since generated a substantial amount of interest in the test procedures he used. It is not our purpose here to categorize either the criticisms which have been directed at Barro's work or the subsequent work which has cast some doubt on the strength of his results.^{3/} As we noted earlier, most of the empirical research done regarding the neutrality implications of the NRH has been conducted using economy-wide data. We believe that taking a microeconomic approach to the problem enables us to avoid some of the areas of controversy while adding some new insights into the mechanism through which money affects output. This can be most easily illustrated by returning attention to the Lucas supply model.

In the Lucas framework, all firms are price-takers in what can be called 'auction' or 'flex-price' markets. In such markets, agents can purchase or sell as much as is desired at the market determined price. However, many industries in the U.S. operate in what have been called 'contract' or 'fixed-price' markets.^{4/} In these markets the concepts of anticipated and unanticipated money need further clarification. Once prices or wages

are fixed, an announced monetary shock can alter real output levels. As papers by Fischer (1977) and Phelps and Taylor (1977) demonstrate, the critical issue is whether a particular shock was unanticipated prior to the fixing of prices. Consider, for example, a contract allowing an agent to purchase an unlimited amount of a good at a specified nominal price. Once the contract has been signed, an announced money shock could increase demand and, hence, production. Shocks which are anticipated prior to the contract agreement would not be expected to alter output. Our point is that conventional monetary forecasting techniques, such as Barro's, do not really yield an appropriate measure of anticipated versus unanticipated money shocks for contract markets. Annual or quarterly forecasting models would not yield anything analogous to pre-contract versus post-contract anticipations. In contract markets anticipated money should be the expected value of the money supply conditioned on the information available at the time of the signing of the contract.

Instead, it would seem useful to examine a particular industry which clearly operates within an auction market. Doing so simplifies the measurement of unanticipated money and, at the same time, purges the data of some possible aggregation problems. Return to our example in which a contract allows a buyer to purchase an unlimited quantity of a good at a specified nominal price. In such circumstances, an increase in the money supply would increase the demand and output. Where are the resources necessary to produce the additional output acquired? The answer, in many cases, is from auction markets. Many union workers, for example, hold temporary jobs during layoffs. An increase in the demand for union workers is met by a reduction in the output of an alternative product. If so, aggregate output could remain invariant to a monetary disturbance, yet announced money shocks could change

the composition of output. The examination of a particular auction market avoids such aggregation problems.

In addition, selection of a particular auction market allows us to trace the effects of monetary changes from producers, to wholesalers, to the market for final product. Studies which focus on the effects of money on real GNP (or final product) cannot trace the effects of money on the short-run vertical structure of an industry. We show, for a specific industry, how money shocks are transmitted throughout the various stages of the production process.

Our study focuses on the pork industry for several important reasons.^{5/}

- 1) The market for pork is clearly an auction market in which there is no direct federal government intervention regarding output price or quantity. Neither the money price nor the relative price (as in agricultural markets in which the support price is tied to a price index) of pork is supported by the government.^{6/}
- 2) Given that the product is essentially homogeneous, we avoid the sometimes difficult issues involved with appropriately defining an industry and/or its output. Further, pork producers (hog breeders and feeders) are distinct from wholesalers (generally large packers such as Hormel, Oscar Meyer, Rath, or Swift) who are distinct from retailers (grocery and butcher shops). As such, it is relatively simple to trace the product through its various stages of processing. Bacon sold at the retail level comes from a 'pork-belly' and there are two bellies per hog slaughtered. Increased retail sales of bacon, will require wholesalers to sell more pork bellies. Bellies can be obtained from inventory (pork bellies in frozen

storage) or current period purchases. In order to increase the number of bellies currently purchased, pork producers must slaughter more animals (and typically, more weight). Data are readily available on weight slaughtered and on pork bellies in frozen storage.

- 3) There is a large body of literature indicating that hog producers do not have rational expectations and that the futures market is not efficient.^{7/} The following reference from Roy, Foote, and Sadler [1976, p. 4] is typical of this literature:

"The phenomenon of the cycles is generally explained on the basis of the cobweb theorem using the hog-corn [price] ratio. A high hog-corn [price] ratio would imply a relatively high price of hogs and a relatively small market supply, and would typically stimulate an increased production in the following period. The longer run adjustments would, however, lead to a relatively abundant supply resulting in a low hog-corn [price] ratio. Subsequently, an unfavorable hog-corn [price] ratio would induce a decrease in farrowings [i.e. number of sows bred and feeder pigs born], which in the succeeding period would lead to reduced market supplies and a relatively high hog price and hog-corn [price] ratio, thus completing the cycle."

We would expect that the money neutrality implications of the NRH would not hold in the circumstance that pork producers had static or adaptive, as opposed to rational, expectations. A final reason, then, for our examination of the pork industry is the large body of literature which would seem to

indicate that money shocks of any sort would alter hog output. If we find evidence to support the money neutrality hypothesis, this would seem to cast serious doubt on the more traditional views of the hog industry as described above.

III. Empirical Results

In this section, the results we obtained from empirically testing the neutrality hypotheses will be summarized and interpreted. The tests were designed to replicate tests used by Barro [1977, 1978, 1981] and Barro and Rush [1980] to evaluate hypotheses which closely parallel ours. Although there has been some criticism of their procedures, criticism which will be made more explicit later in this section, their results have been taken seriously by many macroeconomists.^{8/} We decided to side-step the debate regarding the most effective way to test for neutrality and instead we looked to see whether or not the Barro-Rush tests led us to any interesting conclusions. As we will try to show below, they did.

Complete descriptions of the basic test design and its motivation are offered in the Barro-Rush articles. Here we will simply sketch the outline of the test and note some of its highlights. The generic null hypothesis is that unanticipated money supply changes, but not anticipated money supply changes, influence real economic variables. Let y_t denote the value of a real economic variable at time t . Let m_t^a denote the anticipated rate of growth of the money supply at time t and m_t^u denotes the corresponding unanticipated rate of money growth.^{9/} Next, we assume that y_t evolves according to the following reduced-form, linear model:

$$y_t = \sum_{i=0}^p (\alpha_i m_{t-i}^a + \beta_i m_{t-i}^u + X_{t-i} \psi_i) + u_t \quad (1)$$

In (1), X_t is a $k \times 1$ vector of additional explanatory variables and ψ_i is a $k \times 1$ coefficient vector. The disturbances, u_t , are assumed to be generated independently of the other right-hand-side variables and are serially uncorrelated with mean zero and a constant variance. Then, under the null hypothesis, in (1) all of the α 's are identically zero and at least one of the β 's is not. Under fairly general additional side conditions on these time series, the null hypothesis can be tested by using classical F-tests.^{10/}

For our problem, we were interested in the neutrality hypothesis as it pertains to the rate at which hogs are being slaughtered and the rate at which pork bellies are being accumulated in storage facilities. The actual time series which we used were the growth rate of pounds of hogs being slaughtered per quarter and the growth rate of the average number of pounds of pork bellies being held in frozen storage per quarter. The sample period used was 1960:I to 1975:IV.^{11/}

Since anticipated and unanticipated money supply growth rates are not observable, the procedure requires that realized money supply growth rates be decomposed into anticipated and unanticipated components. In the absence of a fully-developed structural model of money supply determination, an ad hoc, reduced-form model can be used. This is the manner in which the Barro and Rush tests proceeded. They assumed that quarterly money supply growth can be explained by the following model of the Federal Reserve's reaction function:

$$DM_t = a_o + \sum_{i=1}^T b_i DM_{t-1} + \sum_{i=1}^3 c_i U_{t-1} + d_o FEDV_t + v_t \quad (2)$$

In (2), DM_t is the actual growth rate of seasonally adjusted and quarterly M1, U_t is an unemployment rate measure and $FEDV_t$ reflects changes in the size of the federal budget deficit. We will let interested readers consult the original sources [especially, Barro (1977)] for further discussion of this specification. The model was then estimated by OLS. Barro and Rush used the estimated residuals from (2) as a measure of unanticipated money supply growth and used the model's predicted values as their measure of anticipated growth. We did the same thing using the values of these series which they published.^{12/}

Much of the controversy surrounding the Barro-Rush tests has focused on their money supply growth rate model.^{13/} We chose to accept their model largely because it was our original intention to try to replicate the Barro-Rush test procedure unless there were compelling reasons to do otherwise. Looking at some of the alternative specifications of money supply growth models which have been used in this line of research, none seemed to be clearly superior to the Barro-Rush model. Further, Mishkin (1982) and Hoffman and Schlagenhauf (1982) have presented evidence which suggested that the results of these kinds of neutrality tests are likely to be quite robust with regard to alternative, plausible, reduced-form models of the money supply growth process.

A more disconcerting problem which was considered earlier by Abel and Mishkin (1981) can easily arise when the parameters of the output (or

unemployment) reduced-form equation are estimated subject to the first-stage estimates of anticipated and unanticipated money. This two-stage procedure was used by Barro and Rush (and by Barro in most of his earlier work) and we adopted it in this research. If the population covariances between estimates of parameters across the two equations (i.e., money and output equations) are not zero then the two-stage estimator we employ will not be efficient, though its consistency is not affected. In addition, standard errors, t-statistics, etc., calculated in the two-stage procedure without accounting for this kind of covariance will not be theoretically appropriate. As a result, these statistics should be interpreted with (more than the usual amount of) caution.

It is probably worth noting here that Barro [see Barro and Rush (1980)] re-estimated some of his earlier models using a joint estimation procedure and found that his original conclusions regarding money neutrality were generally left unchanged. Mishkin (1982) and Hoffman and Schlagenhauf (1982) used a joint estimation strategy designed by Abel and Mishkin (1981) and rejected Barro's conclusion that anticipated money growth is neutral. However, the discrepancies seem to arise as much from different lag structures used in the output equation as from the different estimators used (or the difference in money supply growth models).

Having accepted the Barro-Rush anticipated-unanticipated money series and their two-stage estimation procedure, it remained for us to fill in the remaining explanatory variables in the output equation, i.e., the elements of X_t in (1). In both the hogs slaughtered and pork bellies in storage cases we included a constant and three seasonal dummy variables. We excluded a time trend because we could not detect one in either growth rate series.

TABLE 1

Summary of Regressions of Hogs Slaughtered
on Unanticipated Money Supply Changes

HOGS = UNANTM0	UNANTM1	UNANTM2	UNANTM3	ANTM0	ANTM1	ANTM2	ANTM3	
2.868 (1.33)	-	-	-	-	-	-	-	SSE = 0.1406 DW = 1.642 T-k = 58 R ² = 0.811
2.813 (1.36)	0.377 (1.41)	-	-	-	-	-	-	SSE = 0.1404 DW = 1.647 T-k = 57 R ² = 0.811
2.865 (1.38)	0.307 (1.44)	0.462 (1.43)	-	-	-	-	-	SSE = 0.1401 DW = 1.635 T-k = 56 R ² = 0.812
2.917 (1.38)	0.249 (1.45)	0.657 (1.46)	-1.203 (1.48)	-	-	-	-	SSE = 0.1385 DW = 1.614 T-k = 55 R ² = 0.814

HOGS = percentage rate of growth of pounds of hogs slaughtered.

PKBL = percentage rate of growth of pounds of pork bellies in frozen storage.

UNANTM1 = percentage rate of growth of money supply, unanticipated, lagged 1 quarters.

ANTM1 = percentage rate of growth of the money supply, anticipated, lagged 1 quarters.

Standard errors are in parentheses. The intercept and seasonal terms have been suppressed.

TABLE 2

Summary of Regressions of Hogs Slaughtered
on Anticipated Money Supply Changes

HOGS = UNANTM0	UNANTM1	UNANTM2	UNANTM3	ANTM0	ANTM1	ANTM2	ANTM3	
-	-	-	-	-0.498 (0.62)	-	-	-	SSE = 0.150 DW = 1.716 T-k = 58 R ² = 0.798
-	-	-	-	-0.543 (0.62)	0.624 (0.61)	-	-	SSE = 0.147 DW = 1.761 T-k = 57 R ² = 0.802
-	-	-	-	-0.578 (0.61)	0.563 (0.61)	0.772 (0.61)	-	SSE = 0.143 DW = 1.804 T-k = 56 R ² = 0.807
-	-	-	-	-0.650 (0.61)	0.529 (0.61)	0.720 (0.61)	0.570 (0.61)	SSE = 0.141 DW = 1.790 T-k = 55 R ² = 0.810

See Table 1 for key.

TABLE 3
Summary of Regressions of Hogs Slaughtered
on Anticipated and Unanticipated Money Supply Changes

HOGS = UNANTMØ	UNANTM1	UNANTM2	UNANTM3	ANTMØ	ANTM1	ANTM2	ANTM3	
2.869 (1.34)	-	-	-	-0.500 (0.598)	-	-	-	SSE = 0.139 DW = 1.656 T-k = 57 R ² = 0.813
2.806 (1.36)	0.552 (1.44)	-	-	-0.590 (0.61)	0.629 (0.60)	-	-	SSE = 0.136 DW = 1.711 T-k = 55 R ² = 0.818
2.767 (1.38)	0.490 (1.46)	0.130 (1.46)	-	-0.619 (0.62)	0.562 (0.61)	0.719 (0.60)	-	SSE = 0.132 DW = 1.741 T-k = 53 R ² = 0.822
2.750 (1.38)	0.426 (1.46)	0.380 (1.47)	-1.793 (1.50)	-0.770 (0.63)	0.523 (0.61)	0.794 (0.61)	0.534 (0.60)	SSE = 0.127 DW = 1.694 T-k = 51 R ² = 0.829

See Table 1 for key.

TABLE 4
Summary of Regressions of Stored Pork Bellies
on Unanticipated Money Supply Changes

PKBL = UNANTM0	UNANTM1	UNANTM2	UNANTM3	ANTM0	ANTM1	ANTM2	ANTM3	
-14.578 (7.11)	-	-	-	-	-	-	-	SSE = 3.997 DW = 1.853 T-k = 58 R ² = 0.9202
-16.073 (7.13)	10.275 (7.41)	-	-	-	-	-	-	SSE = 3.867 DW = 1.792 T-k = 57 R ² = 0.9228
-16.706 (7.21)	11.129 (7.52)	-5.645 (7.48)	-	-	-	-	-	SSE = 3.828 DW = 1.778 T-k = 56 R ² = 0.9236
-16.870 (7.26)	11.312 (7.58)	-6.259 (7.65)	3.783 (7.76)	-	-	-	-	SSE = 3.812 DW = 1.763 T-k = 55 R ² = 0.9239

See Table 1 for key.

TABLE 5
Summary of Regressions of Stored Pork Bellies
on Anticipated Money Supply Changes

PKBL = UNANTMØ	UNANTM1	UNANTM2	UNANTM3	ANTMØ	ANTM1	ANTM2	ANTM3	
-	-	-	-	-1.642 (3.28)	-	-	-	SSE = 4.2691 DW = 1.9993 T-k = 58 R ² = 0.9148
-	-	-	-	-1.613 (3.32)	-0.409 (3.28)	-	-	SSE = 4.2680 DW = 1.9989 T-k = 57 R ² = 0.9148
-	-	-	-	-1.624 (3.35)	-0.429 (3.32)	0.249 (3.31)	-	SSE = 4.2675 DW = 1.9986 T-k = 56 R ² = 0.9148
-	-	-	-	-1.563 (3.41)	-0.400 (3.36)	0.294 (3.35)	-0.487 (3.35)	SSE = 4.2659 DW = 1.9884 T-k = 55 R ² = 0.9149

See Table 1 for key.

TABLE 6
Summary of Regressions of Stored Pork Bellies
on Anticipated and Unanticipated Money Supply Changes

PKBL = UNANTMØ	UNANTM1	UNANTM2	UNANTM3	ANTMØ	ANTM1	ANTM2	ANTM3	
-14.573 (7.15)	-	-	-	-1.634 (3.20)	-	-	-	SSE = 3.9792 DW = 1.8656 T-k = 57 R ² = 0.9206
-16.263 (7.22)	11.495 (7.64)	-	-	-2.513 (3.26)	-0.706 (3.17)	-	-	SSE = 3.8205 DW = 1.8055 T-k = 55 R ² = 0.9238
-16.891 (7.37)	12.231 (7.83)	-5.478 (7.98)	-	-2.250 (3.30)	-0.319 (3.27)	0.472 (3.21)	-	SSE = 3.7843 DW = 1.7947 T-k = 53 R ² = 0.9245
-16.977 (7.53)	12.331 (7.97)	-5.953 (8.04)	3.095 (8.20)	-2.357 (3.41)	-0.296 (3.34)	0.273 (3.33)	-0.141 (3.28)	SSE = 3.7738 DW = 1.7789 T-k = 51 R ² = 0.9247

See Table 1 for key.

A summary of the regressions we ran is presented in Tables 1-6. We have excluded from the tables a report on the estimated coefficients on the constant and seasonal variables in order to highlight the coefficients on money supply growth. The high R-squares reported, however, are largely due to our picking up the strong seasonal components in both series. The important point to notice is that we cannot reject the hypothesis that unanticipated, and only unanticipated, money supply variables influence slaughters and bellies in storage.

In the regressions which include current and lagged values of anticipated and unanticipated money supply growth rates, the only estimated coefficients which had t-ratios which differed significantly from zero at the five percent significance level were the coefficients on current unanticipated money. In the case of slaughtered hogs, with 51 degrees of freedom, the t-ratio was calculated to be 1.99 while in the case of stored pork bellies the t-ratio was calculated to be -2.26. The conclusion that only current unanticipated money supply growth enters the model with a significant coefficient did not depend on the number of lagged values of unanticipated money supply growth which were simultaneously present. Neither did it depend on the presence of current and lagged values of anticipated money supply growth.

Also notice that the magnitude of the coefficients on current unanticipated money are quite reasonable. With respect to the growth rate of pork slaughtered, the point estimate of the coefficient on the unanticipated, current growth rate of the money supply hovers in the neighborhood of 2.7 to 3.0. Since the sample mean of the (absolute value of the) unanticipated growth rate of the money supply is about 0.0038, this means that our model predicts that a typical unanticipated money supply growth shock of 0.38

percent would lead to a contemporaneous increase of about one percent in the number of pounds of hogs slaughtered. The direction of the change is consistent with our original conjecture that by falsely signalling an increase in the relative price of hogs, breeders would respond to the unforeseen increase in the money supply by moving hogs to slaughter more rapidly.

With respect to the growth rate of pork bellies being held in storage, the point estimate of the coefficient on the unanticipated, current growth rate of the money supply varies from about -14.5 to -17.0. In other words, our estimates suggest that a typical (over the sample) unanticipated increase in the money supply of about 0.38 percent would have caused a contemporaneous decrease in stored pork bellies of about 5.5 to 6.5 percent. Again, the direction of change is consistent with our original conjecture. The unanticipated money supply increase falsely signals wholesalers of an increase in the relative price of pork bellies, inducing them to reduce their inventories. It is interesting to note that the response of pork bellies is much larger (in percentage terms) than is the response of hogs slaughtered. This is to be expected since there is much more flexibility in the case of when stored pork bellies should be sold than in the case of when a hog should be slaughtered.

We also performed F-tests to determine whether groups of coefficients on lagged unanticipated money and/or current and lagged anticipated money were significant. We varied the number of lags we included as well as doing the tests with anticipated and/or unanticipated money. As can be inferred from the summary statistics included in Tables 1-6, we did not uncover any significant groups at the 5% significance level. Thus, we can reject the hypothesis (at the 5% level) that unanticipated money supply changes have a persistent effect on stored pork bellies and meat slaughtered.

We do so, however, with some caution because these test statistics were calculated using Barro's two-step procedures.

If we examine the point estimates of the lagged unanticipated money coefficients, some interesting patterns emerge (recall Barro's estimation, while inefficient, is consistent). In the pork belly model, the coefficients on lagged unanticipated money exhibit damped oscillations. This could be explained on the basis of an optimal inventory model. An initial unanticipated money shock induces wholesalers to reduce bellies in storage. In the subsequent period, bellies in storage increase -- all else equal -- to make up for a portion of the previous periods' response to unanticipated money. An interesting pattern also appears in the pounds slaughtered equations. Note that there is a relatively large negative coefficient on unanticipated money lagged three quarters. When we extended the numbers of lags to six, the sixth lag had a relatively large negative coefficient.^{14/} This is quite consistent with the technology utilized by pork breeders. Hogs not slaughtered are added to the breeding stock; nearly all such hogs are nine to ten month old females (gilts). Breeding occurs several months later and the gestation period is nearly four months. Sows (females that have been bred) suckle their litters for something less than 2 months. This could explain our three and six quarter lags on unanticipated money. Consider an unanticipated reduction in the money supply which led to an increase in the breeding stock (fewer slaughters). Three quarters later some sows which had suckled their litters would be slaughtered. Nearly six quarters from the unanticipated money shock, some of the pigs from the sows' litters could be marketed.

IV. Conclusions

We have provided some additional empirical support for the Natural Rate Hypothesis. Anticipated changes in the money supply were shown to have no significant effects in the pork industry. Unanticipated shocks, however, affect pork output in a manner which is consistent with the Lucas supply mechanism. An unanticipated increase in the money supply causes more hogs (by weight) to be slaughtered, reduces pork bellies in frozen storage, and (implicitly) increases pork sales at the retail level.

Examination of a particular industry allowed us to avoid some of the problems inherent in aggregative tests of the Natural Rate Hypothesis. It also allowed us to trace the effects of unanticipated shocks throughout an industry. Note that our results are inconsistent with the view that pork producers form their expectations in a simplistic manner. Rather, we show that the data is consistent with the view that agents in the pork industry form their expectations rationally.

We believe that it would be useful to expand our approach to consider a wide spectrum of industries. In particular, it would be insightful to compare the results concerning a set of industries operating in auction markets to results concerning a set of industries operating in contract or fixed-price markets. A second extension would be to examine the sensitivity of our results to alternative, and possibly more efficient, estimation strategies.

Footnotes

* Iowa State University

We would like to thank Roy Adams, William Meyers, John Miranowski, and Peter Orazem for their helpful comments. Tony Albrecht provided research assistance.

1. Interested readers should also consult Barro (1976) which extends the seminal Lucas (1972) and Lucas (1973) articles in several important ways. Barro also specifies many of the assumptions which are implicit in Lucas' work.
2. In particular, see Barro (1977) and Barro and Rush (1980).
3. Many of these criticisms can be found in Fischer (1980).
4. Hicks (1969) and Gordon (1981) provide interesting discussions of the differences between fixed-price and flex-price markets.
5. The structure of the pork market is discussed in great detail in Van Arsdall (1978).
6. If, as in certain agricultural markets, the government pegged the nominal price, we would have a fixed-price market. Money shocks, either anticipated or unanticipated, would affect output. In the other extreme, one in which the government ties the support price to a price index, the relative price would tend to be invariant to money shocks. Money shocks of any sort, would not be expected to alter the decisions of optimizing agents.
7. For example, Leuthold and Hartmann (1979) argue that the futures market in hogs is not efficient. Other references can be found in the detailed bibliography by Brandt and Roth (1980).

8. For example, several of Barro's papers along this line are included in the Lucas and Sargent [1981] collection of papers on rational expectations. The Barro and Rush paper is included in Fischer's [1980] collection of papers on that area. Further, the papers cited in this paper's introductory paragraph were stimulated partly by Barro's earlier work.
9. Here we refer to the expectations of the economic agents who are choosing y_t .
10. For example, if y_t , m_t^a , m_t^u , X_t and u_t form a jointly stationary and ergodic stochastic process.
11. The data on slaughtered hogs and stored pork bellies are available from Agricultural Statistics.
12. These series were published in Barro and Rush (1980).
13. See, for example, the discussion accompanying the Barro and Rush (1980) article and Mishkin's (1982) article.
14. The regression is summarized below, with standard errors in parentheses and the constant and seasonal terms suppressed

$$\begin{aligned}
 \text{HOGS} = & 3.02 \text{ UNANT0} + 0.21 \text{ UNANT1} + 0.17 \text{ UNANT2} - 1.43 \text{ UNANT3} \\
 & (1.53) \quad (1.60) \quad (1.56) \quad (1.59) \\
 & + 0.45 \text{ UNANT4} - 0.41 \text{ UNANT5} - 2.29 \text{ UNANT6} \\
 & (1.69) \quad (1.71) \quad (1.67)
 \end{aligned}$$

$$\text{SSE} = 0.129, \text{ DW} = 1.59, \text{ T-k} = 49, \text{ R}^2 = 0.817$$

References

- Abel, Andrew B. and Mishkin, Fredric S. "An Integrated View of Tests of Rationality, Market Efficiency and the Short-Run Neutrality of Monetary Policy." Report no. 8113, Center Math. Studies Bus. and Econ., University of Chicago, March 1981.
- Barro, Robert J. "Rational Expectations and the Role of Monetary Policy." Journal of Monetary Economics 2, (January 1976): 1-32.
- _____. "Unanticipated Monetary Growth and Unemployment in the United States." American Economic Review 67 (March 1977), 101-115.
- _____. "Unanticipated Money, Output, and the Price Level in the United States." Journal of Political Economy 86, (August 1978): 549-80.
- _____. "Unanticipated Money, Output, and the Price Level in the United States," in R. Barro (ed.), Money, Expectations, and Business Cycles (New York: Academic Press, 1981).
- Barro, Robert J. and Mark Rush. "Unanticipated Money and Economic Activity," in Stanley Fischer (ed.) Rational Expectations and Economic Policy. (Chicago: University of Chicago Press, 1980).
- Brandt, Jon A. and Michael Roth. Annotated Bibliography of Research on the Hog-Pork Industry. (West Lafayette, Indiana: Purdue University, 1980).
- Fischer, Stanley. "Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule," Journal of Political Economy 85, (Feb. 1977), 191-206.
- _____. Rational Expectations and Economic Policy. (Chicago: University of Chicago Press, 1980).
- Gordon, Robert J. "Output Fluctuations and Gradual Price Adjustment," Journal of Economic Literature 19, (June 1981), 493-530.

Hicks, John. Capital and Growth. (London: Oxford Univ. Press, 1965).

Hoffman, Dennis, L. and Don E. Schlagenhauf. "An Econometric Investigation of the Monetary Neutrality and Rationality Propositions From an International Perspective." Review of Economics and Statistics. (Nov. 1982), 562-571.

Leuthold, Raymond M. and Peter A. Hartmann. "A Semi-Strong Form Evaluation of the Efficiency of the Hog Futures Market." American Journal of Agricultural Economics 61, (Aug. 1979), 482-489.

Liederman, Leonardo. "Macroeconomic Testing of the Rational Expectations and Structural Neutrality Hypotheses for the United States." Journal of Monetary Economics 6, (January 1980): 69-82.

Lucas, Robert E., Jr. "Econometric Testing of the Natural Rate Hypothesis," in Otto Eckstein (ed.), The Econometrics of Price Determination Conference. (Wash., D.C.: Board of Governors of the Federal Reserve System, 1972), 50-59.

_____. "Some International Evidence on Output-Inflation Tradeoffs." American Economic Review 63, (June 1973), 326-334.

_____. and Thomas Sargent, eds. Rational Expectations and Econometric Practice. (Minneapolis: University of Minnesota Press, 1981).

Mishkin, Fredric S. "Does Anticipated Monetary Policy Matter? An Econometric Investigation." Journal of Political Economy 90, (February 1982): 22-51.

Phelps, Edmund S. and John B. Taylor. "Stabilizing Powers of Monetary Policy Under Rational Expectations." Journal of Political Economy 85, (Feb. 1977), 163-190.

Roy, Sujit H. Richard J. Foote and George Sadler. Econometric Models of Quarterly and Monthly Live Hog Prices. (Lubbock, Texas: Texas Tech. University, 1976).

Sargent, Thomas J. and Neil Wallace. "Rational Expectations and the Theory of Economic Policy," in R. E. Lucas, Jr. and Thomas J. Sargent (eds.) Rational Expectations and Econometric Practice. (Minneapolis: University of Minnesota, 1981): 199-213.

Small, David H. "Unanticipated Money Growth and Unemployment in the United States: Comment." American Economic Review 69, (December 1979): 996-1003.

Van Arsdall, Roy N., Structural Characteristics of the U.S. Hog Production Industry. (Wash. D.C.: United States Dept. of Agriculture, 1978).